Electrochemical Energy Storage – A System's Perspective

"The Role of Electrochemical Energy Storage in the Energy Transition"

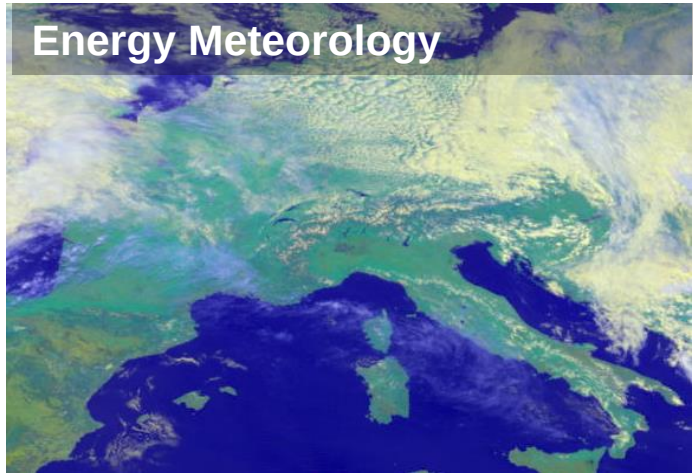
Kickoff POF IV

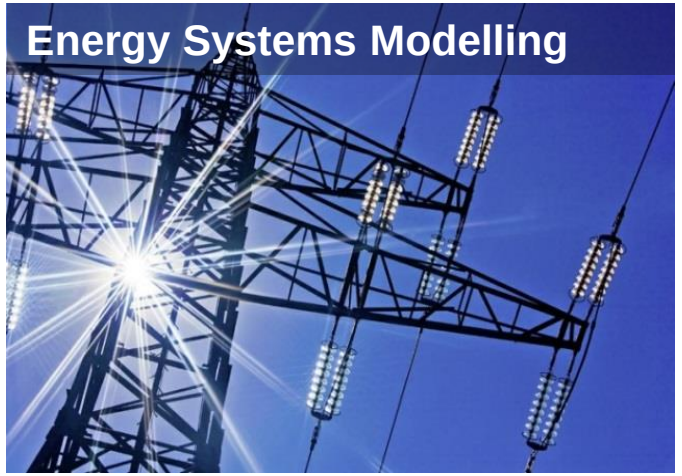
Karl-Kiên Cao, Hans Christian Gils, Manuel Wetzel
German Aerospace Center
Institute of Networked Energy Systems

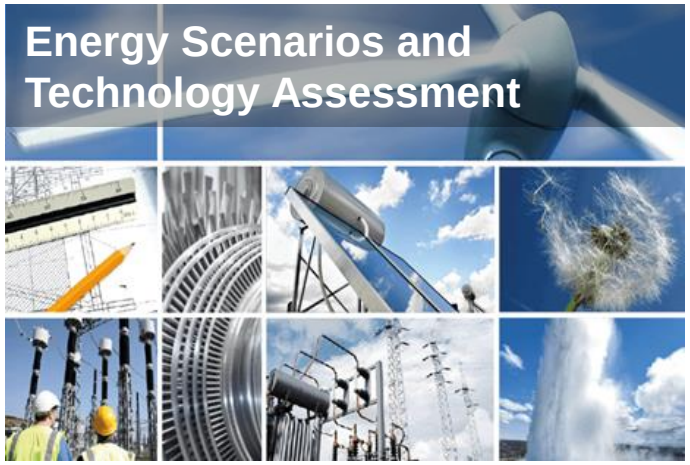
2. July 2021

Which systems?

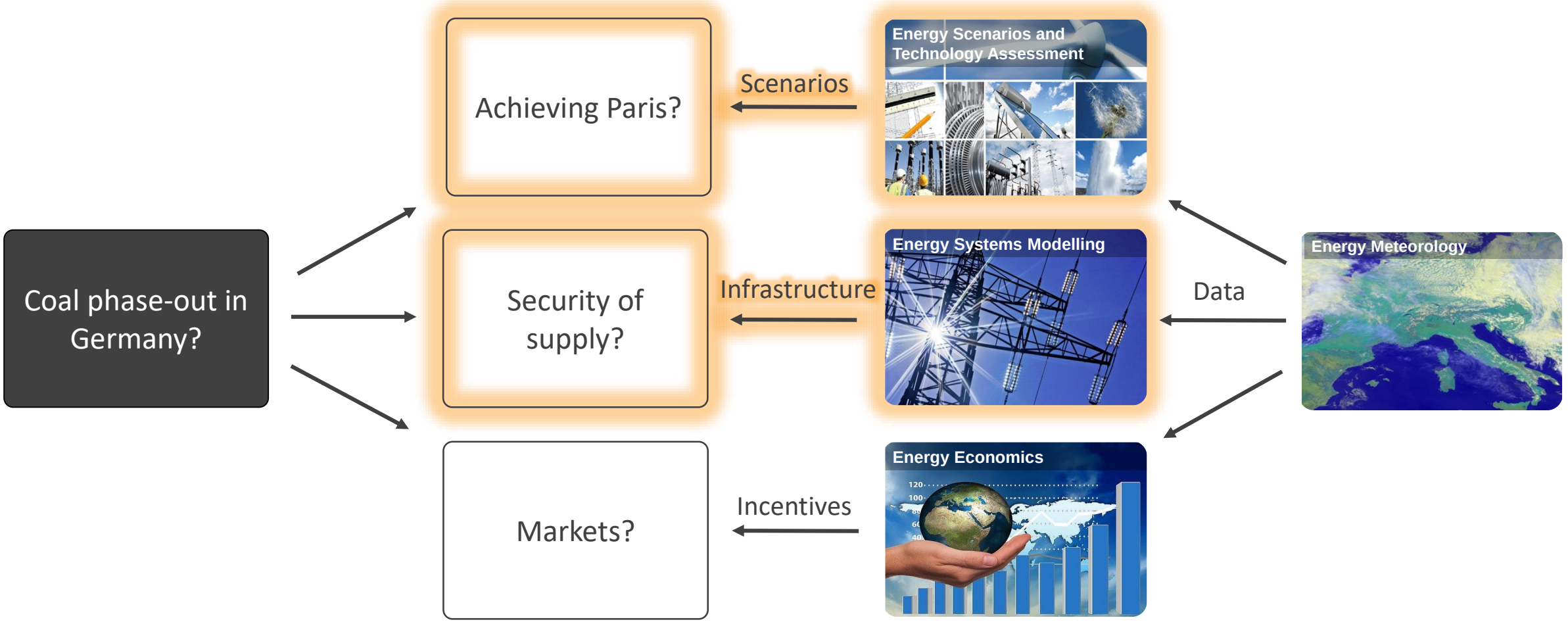
Energy Systems Analysis at DLR



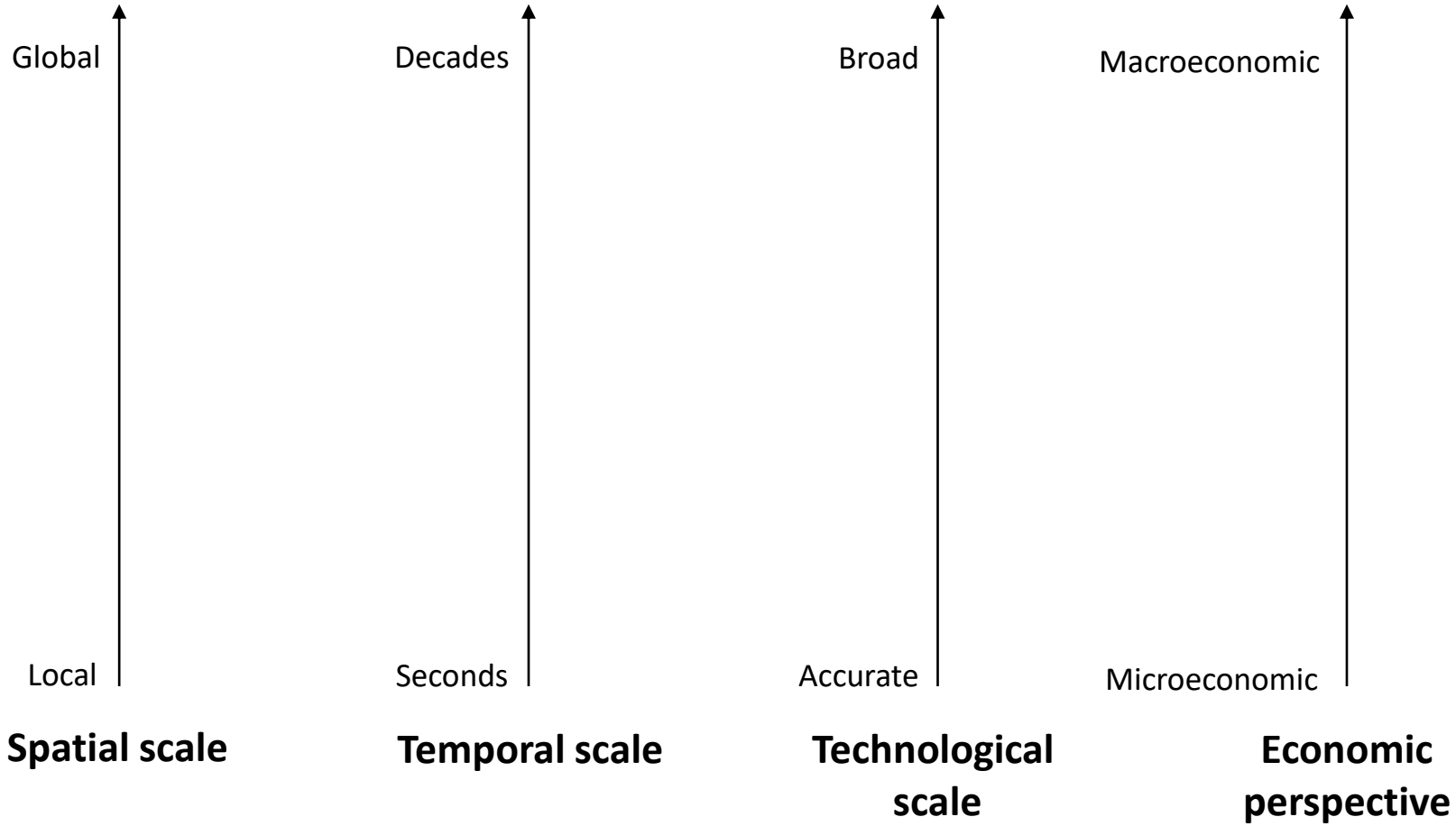




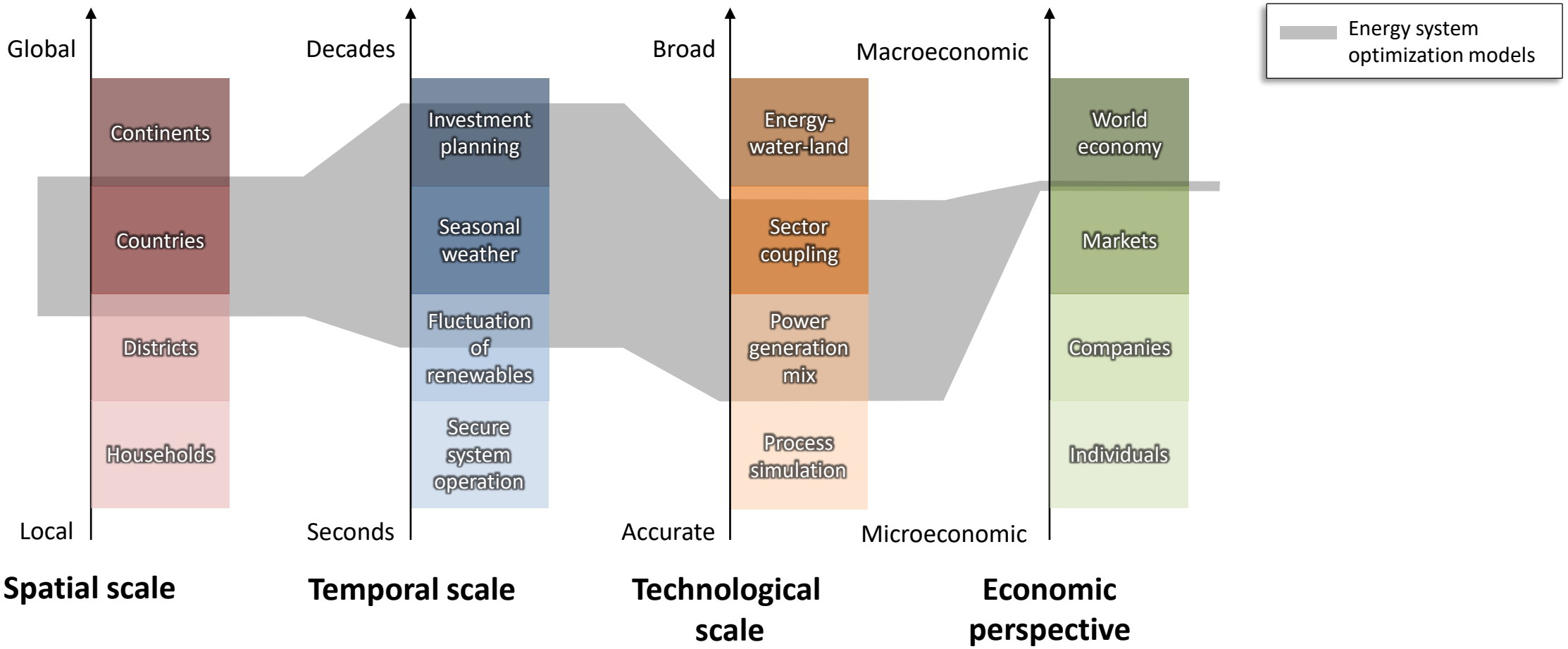
Energy Systems Analysis at DLR: An example



Scopes in Energy Systems Analysis



Modeling scenarios of future energy systems



Source: Cao, Karl-Kien und Haas, Jannik und Sperber, Evelyn und Sasanpour, Shima und Sarfarazi, Seyedfarzad und Pregger, Thomas und Alaya, Oussama und Lens, Hendrik und Drauz, Simon R. und Kneiske, Tanja (2021) *Bridging granularity gaps to decarbonize large-scale energy systems - The case of power system planning.* Energy Science and Engineering. Wiley. doi: 10.1002/ese3.891

Electrochemical Energy Storage – A System's Perspective

"The Role of Electrochemical Energy Storage in the Energy Transition"

Karl-Kiên Cao, Hans Christian Gils, Manuel Wetzel
German Aerospace Center
Institute of Networked Energy Systems

2. July 2021

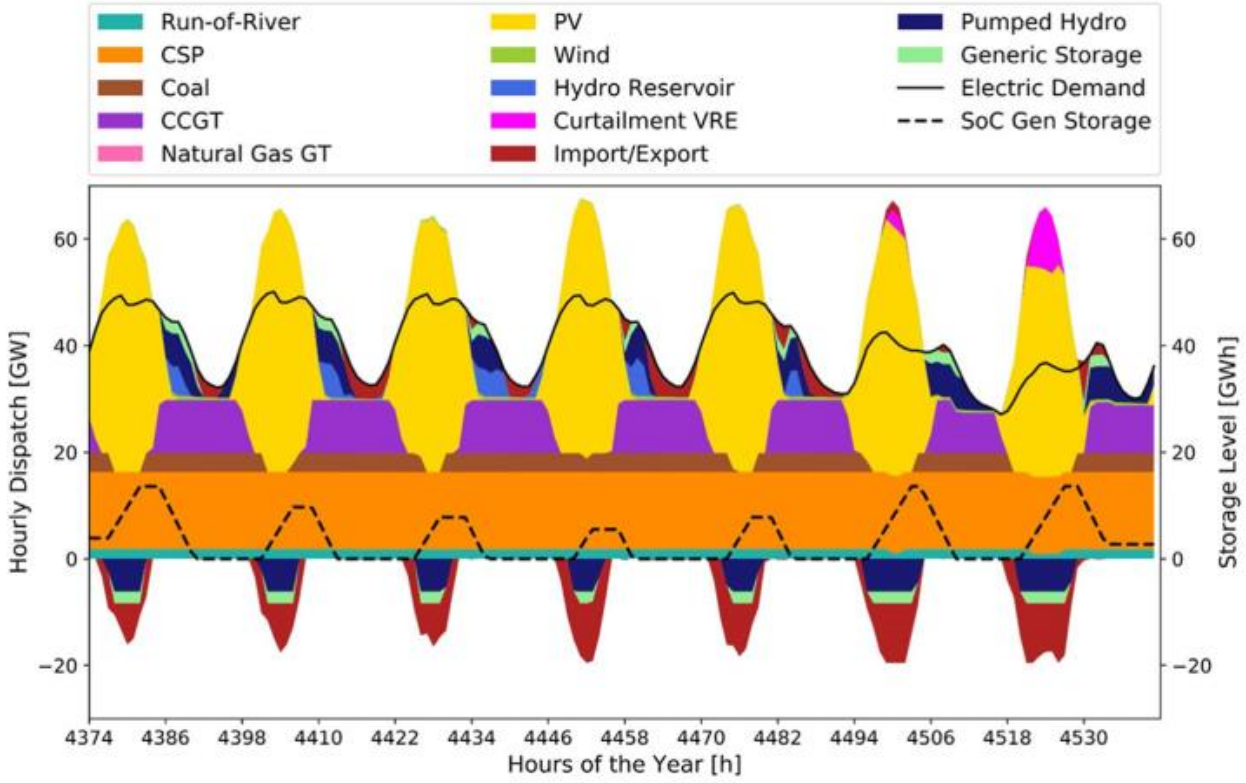
Key findings

Electrochemical storage…

1. … is for short-term load-balancing
2. … is particularly important in PV dominated systems
3. … is one option among many for load-balancing
4. … poses challenges due to life-cycle based GHG emissions of PV-battery systems

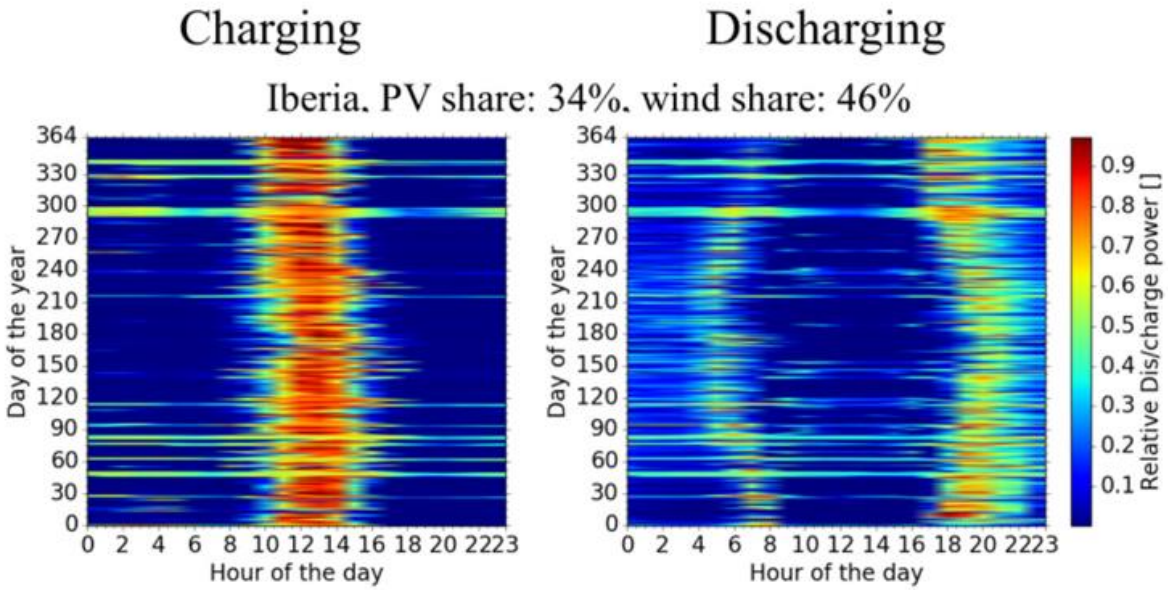
Short-term load-balancing

Hourly power generation by technology in Iberia

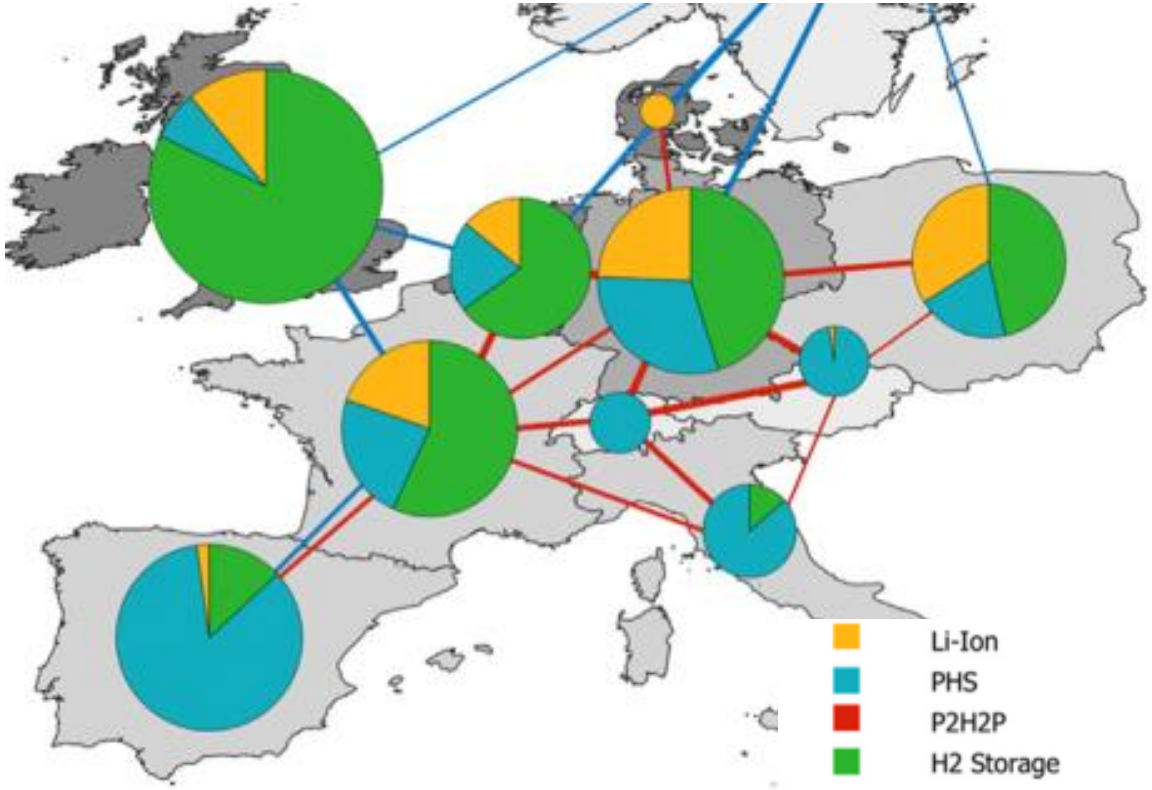


Short-term load-balancing

Battery storage operation in Iberia



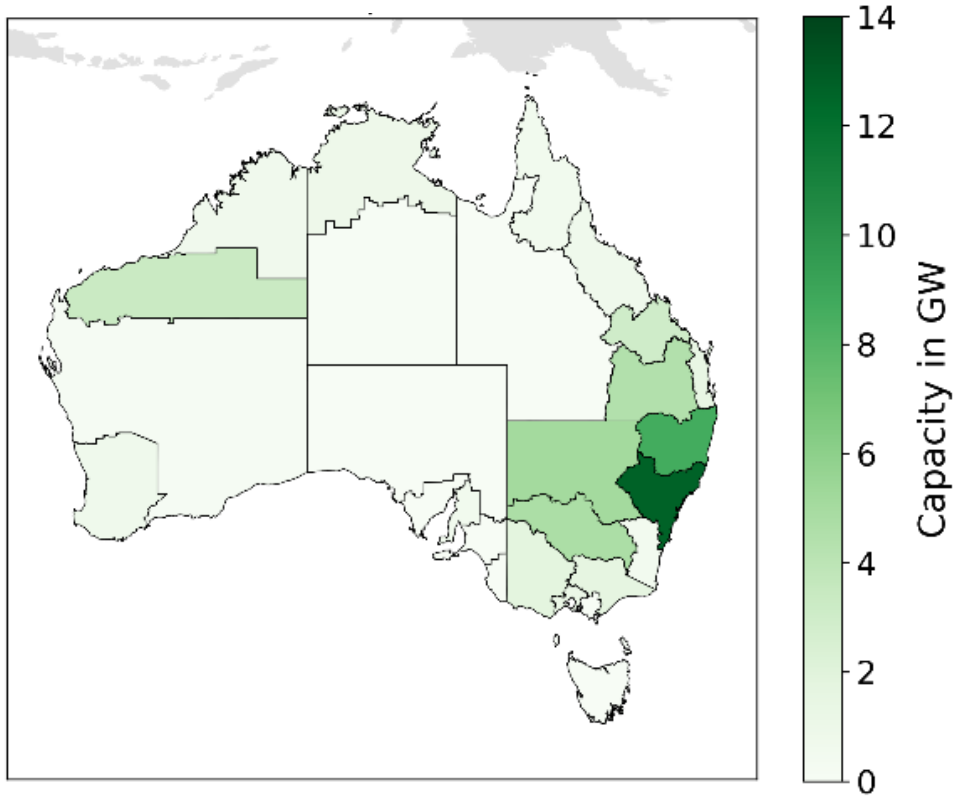
Installed storage @80% RE power supply



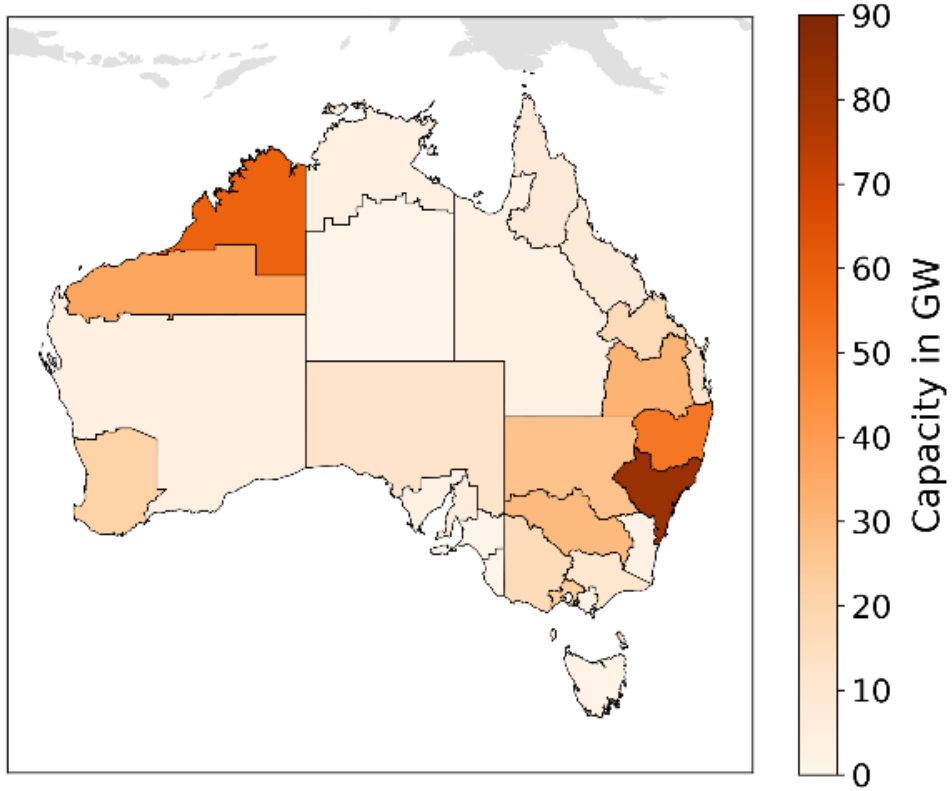
Sources: Cebulla, Felix (2017) Storage demand in highly renewable energy scenarios for Europe : The influence of methodology and data assumptions in model-based assessments. Dissertation;
Moser, M., Gils, H.C., Pivaro, G. (2020) A sensitivity analysis on large-scale electrical energy storage requirements in Europe under consideration of innovative storage technologies, Journal of Cleaner Production, 269, 122261, https://doi.org/10.1016/j.jclepro.2020.122261

Short-term (battery) storage: important in PV-dominated systems

Installed capacity of LI-batteries

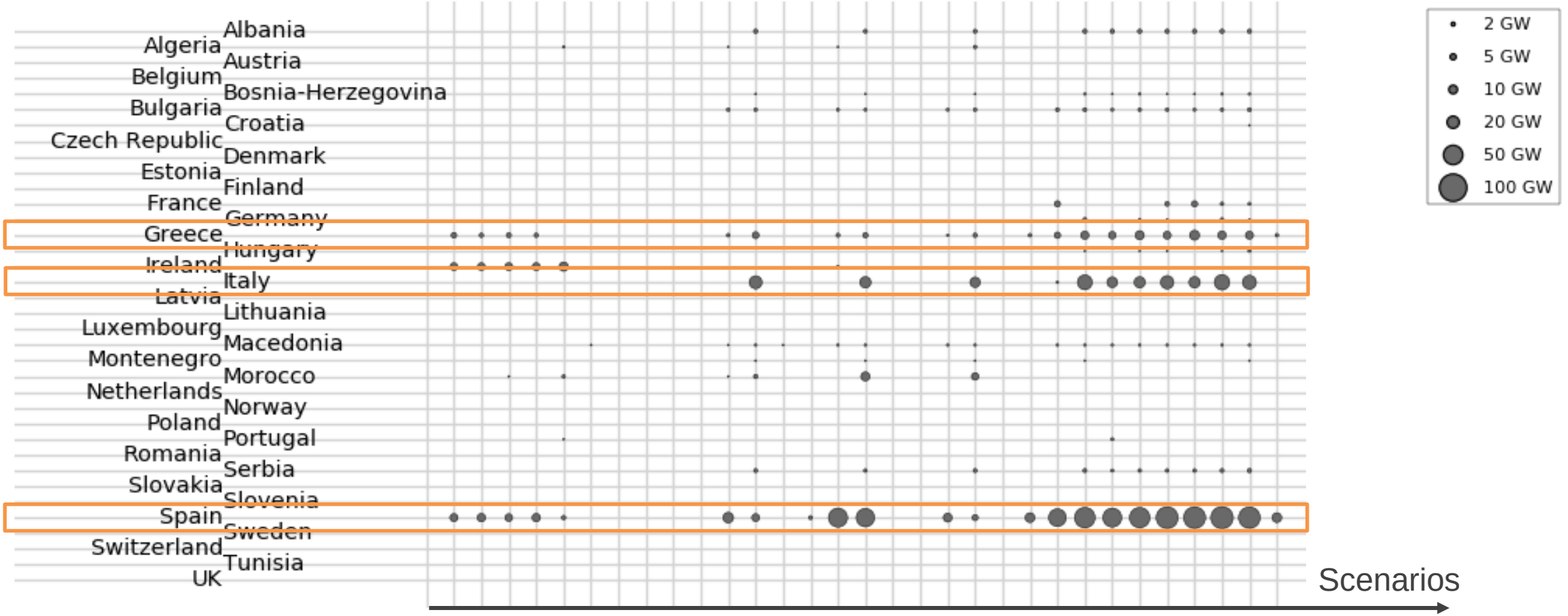


Installed capacity of photovoltaics



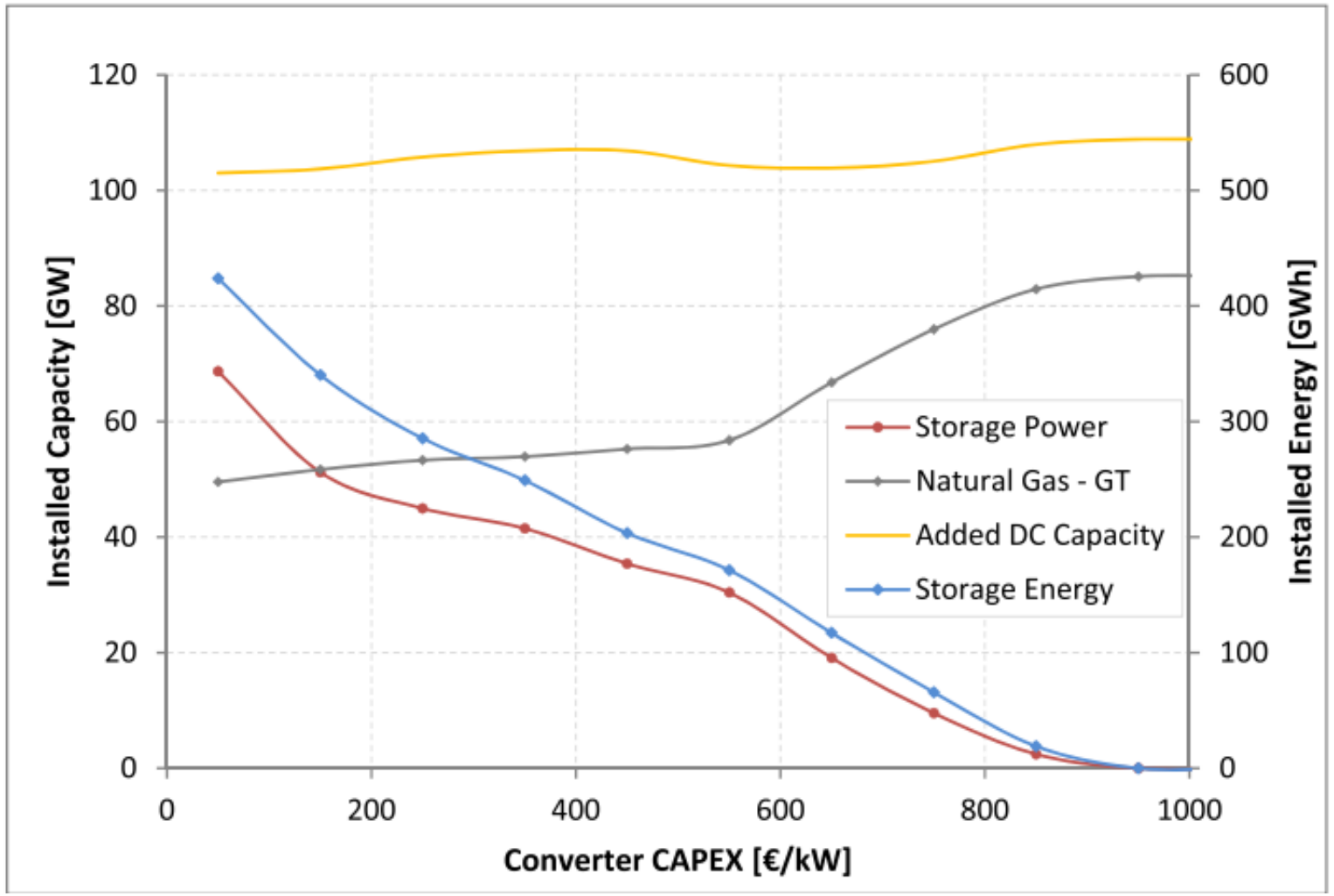
Source: Gils, H.C., et al (2020) Strategic Scenario Analysis – A first German-Australian focus project (START), final report DLR, https://elib.dlr.de/140611/
Ueckerdt et al. (2019) Australia's power advantage - Energy transition and hydrogen export scenarios, https://elib.dlr.de/131952/

Installed battery storage in >30 energy scenarios of Europe



Source: K. -K. Cao and T. Pregger, "Grid Expansion, Power-To-Gas and Solar Power Imports - Multi-Scenario Analysis of Large Infrastructure Options for the Decarbonization of the," International ETG-Congress 2019; ETG Symposium, 2019, pp. 1-6.

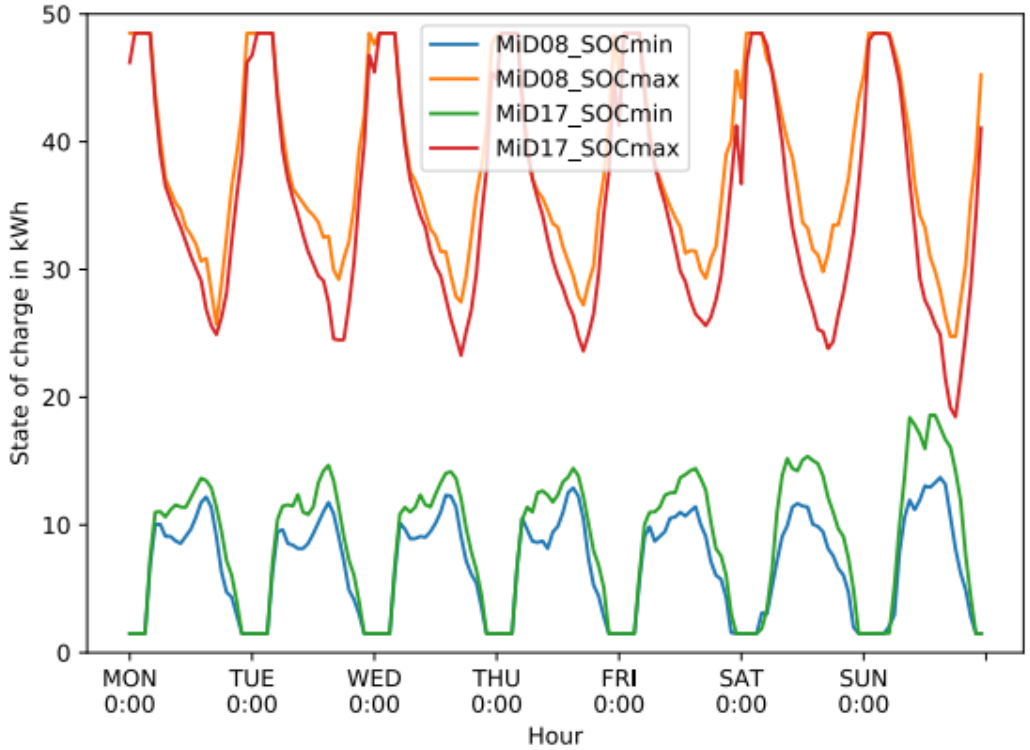
A matter of costs



Source: Moser, M., Gils, H.C., Pivaro, G. (2020) A sensitivity analysis on large-scale electrical energy storage requirements in Europe under consideration of innovative storage technologies, Journal of Cleaner Production, 269, 122261, https://doi.org/10.1016/j.jclepro.2020.122261

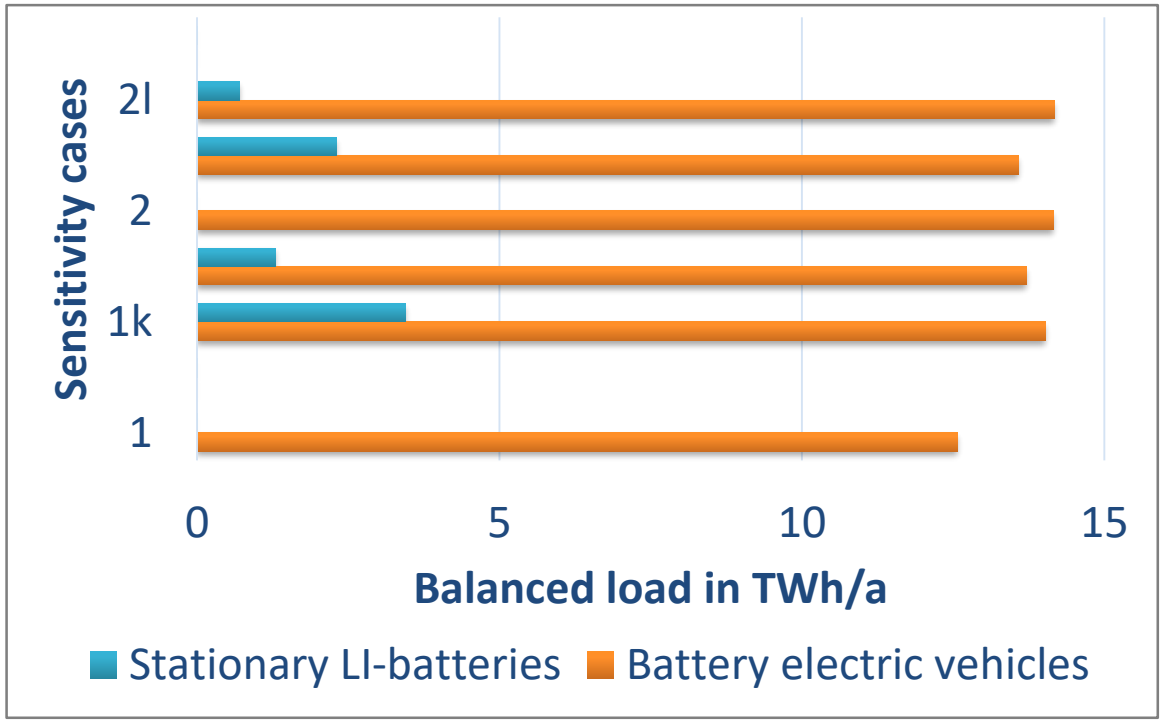
Load-balancing by mobile and stationary battery applications

Temporally resolved availability of e-vehicles



Source: Wulff, N., Miorelli, F., Gils, H.C. (2021) Vehicle Energy Consumption in Python: Presenting and demonstrating an open source tool to calculate electric vehicle charging flexibility, submitted to Energies

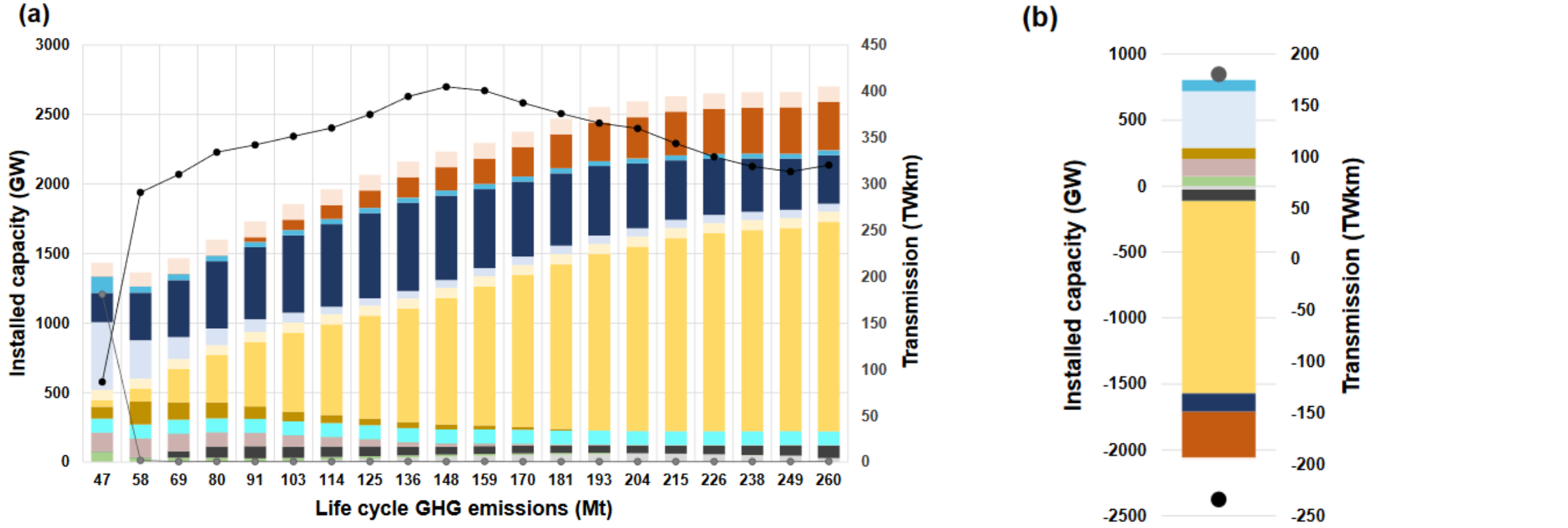
Results from German energy scenarios



Source: Wulff, Niklas und Steck, Felix und Gils, Hans Christian und Hoyer-Klick, Carsten und Van den Adel, Bent und Anderson, John (2020) Comparing Power-System and User-Oriented Battery Electric Vehicle Charging Representation and its Impact on Energy System Modeling. Energies, 13 (5) doi: 10.3390/en13051093.

GHG reduction from a life-cycle perspective

From minimal GHG to minimal cost (a) and the differences between these minima (b)



Source: Junne, Tobias und Cao, Karl-Kien und Miskiw, Kim Kira und Hottenroth, Heidi und Naegler, Tobias (2021) Considering Life Cycle Greenhouse Gas Emissions in Power System Expansion Planning for Europe and North Africa Using Multi-Objective Optimization. Energies, 14. Multidisciplinary Digital Publishing Institute (MDPI). doi: 10.3390/en14051301.

Key findings

Electrochemical storage…

1. … is for short-term load-balancing
2. … is particularly important in PV dominated systems
3. … is one option among many for load-balancing
4. … poses challenges due to life-cycle based GHG emissions of PV-battery systems

Thank you!

Dr. Karl-Kiên Cao

Deutsches Zentrum für Luft- und Raumfahrt
Institut für Vernetzte Energiesysteme
Energiesystemanalyse
Karl-Kien.Cao@dlr.de